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E82-10226
CR-168800

QUARTERLY STATUS AND TECHNICAL

PROGRESS REPORT #5

**INVESTIGATION OF THE EFFECTS OF EXTERNAL CURRENT SYSTEMS
ON THE MAGSAT DATA UTILIZING GRID CELL MODELING TECHNIQUES**

**NASA CONTRACT NO. NAS5-26309
UTD #0533-01**

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**(E82-10226) INVESTIGATION OF THE EFFECTS OF
EXTERNAL CURRENT SYSTEMS ON THE MAGSAT DATA
UTILIZING GRID CELL MODELING TECHNIQUES
Quarterly Status Technical Progress Report,
1 Oct. - 31 Dec. 1981 (Texas Univ. at**

N82-23599

Unclas

G3/43 00226

Period Reported: 1 October 1981 - 31 December 1981

Date of Submission: 9 January 1982

RECEIVED

Submitted to

JAN 19, 1982

**NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771**

SIS/902.6

M-013

TYPE II

January 1982

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 5	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Investigation of the Effects of External Current Systems on the MAGSAT Data Utilizing Grid Cell Modeling Techniques		5. Report Date January 9, 1982	
		6. Performing Organization Code	
7. Author(s) David M. Klumpar		8. Performing Organization Report No.	
9. Performing Organization Name and Address Center for Space Sciences The University of Texas at Dallas P.O. Box 688 Richardson, TX 75080		10. Work Unit No.	
		11. Contract or Grant No. NAS5-26309	
12. Sponsoring Agency Name and Address Harold Oseroff, Code 902 NASA/Goddard Space Flight Center Greenbelt, MD 20771		13. Type of Report and Period Covered Quarterly Status 10/1/81 - 12/31/81	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
<p>16. Abstract</p> <p>The overall objective of this effort in support of the Magsat project is to study the feasibility of modeling magnetic fields due to certain electrical currents flowing in the earth's ionosphere and magnetosphere. This fifth quarterly status and technical progress report discusses progress made in reading Magsat data tapes and plotting the deviation of the measured magnetic field components with respect to a spherical harmonic model of the main geomagnetic field. The report also describes initial tests of the modeling procedure that has been developed to compute the magnetic fields at satellite orbit due to current distributions in the ionosphere and magnetosphere. The modeling technique utilizes a linear current element representation of the large-scale space-current system.</p>			
17. Key Words (Selected by Author(s)) Magsat Magnetic Fields Birkeland Currents		18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 10	22. Price*

I. INTRODUCTION

The overall goal of this investigation is to study the feasibility of modeling the magnetic fields produced by certain electrical currents flowing in the earth's ionosphere-magnetosphere system. Vector magnetic field measurements from the near-polar orbiting Magsat satellite contain, in addition to the main geomagnetic field and crustal anomaly fields, contributions that arise from these external currents. In fulfilling the ultimate goals of the Magsat project, it is desirable that the external current effects be identified in the observations and subsequently separated from the internal field. The objective of this investigative effort will be to determine the capability of a modeling procedure to facilitate the separation of these external and internal components.

The approach of this feasibility study shall be to develop forward modeling procedures through which the magnetic effects of model currents may be derived. It is intended to include, separately, the equatorial electrojet, S_q currents, and the effects due to auroral zone and polar cap currents including the high latitude ionosphere-magnetosphere coupling currents. In each case candidate current systems will be devised and resulting "typical" magnetic field signatures calculated for comparison with Magsat observations.

II. ACCOMPLISHMENTS DURING REPORTING PERIOD

1. Data Reduction

In previous quarterly reports, we have discussed the development of software programs to read the Magsat Chronicle format data tapes on a U.T.D. PDP 11/45 computer, to printout either the orbital data alone or both orbital and

magnetic field-values from both scalar and vector magnetometers for a specified time period contained on the source tape, and to plot using a high resolution interactive vector graphics terminal each of three resultant magnetic components and the scalar field deviations with respect to a spherical harmonic model field.

The graphics capability for visualizing the Magsat observations as deviations with respect to a spherical harmonic main field model is illustrated in the accompanying figures. Figure 1 shows from top to bottom the deviations in the North, East, Vertical components, and the scalar magnitude deviation with respect to the MGST (6/80) spherical harmonic field model for the Magsat orbit over the northern hemisphere from 10:51 - 11:20 UT on November 13, 1979. The polar dial on the right hand side of the figure depicts the location of the satellite in an Invariant Latitude/Magnetic Local Time coordinate system for reference to the data plot. Perturbations in all three vector components, but particularly in the E-W component, are evident as the satellite passes through the Birkeland current system near the dusk and dawn locations of the auroral oval centered near 60° invariant latitude. This plot shows the large-scale features over a 30-minute portion of the orbit with a plotted resolution of two-seconds along the satellite orbit. In order to examine details and finer scale perturbations, the graphics routine developed at UTD has the capability to "home in" on a selected time interval and plot the observations at higher resolution. This capability is illustrated in figure 2 where now only a five-minute portion of the data of figure 1 are presented over that segment of the orbit that crosses the dawn sector of the Birkeland current system. In this plot the resolution has been increased by a factor of 2 to one-second along the orbit. A number of small-scale features are now visible on this plot that were unresolved in figure 1.

It is sometimes useful to view the magnetic perturbations as they would appear in an alternate coordinate system. Figure 3 illustrates the effect of a

coordinate transformation to a system in which the field vector is resolved into components along (S) and perpendicular (D) to the earth-sun line. In this coordinate system the polar cap top hat in the sunward-antisunward component of the magnetic field, often attributed to magnetospheric convection, stands out quite clearly as a positive perturbation in the S component at invariant latitudes above 69° . Note in this figure that the D component perturbation at these high latitudes is essentially zero, in sharp contrast to figure 1 in which the polar top hat contributed about equally to the N and E components.

2. Field Modeling

Previous quarterly status reports have described the development of a modeling technique to describe the magnetic perturbations produced at satellite orbit by an assumed ionospheric and Birkeland current system. This modeling routine is currently undergoing testing of its various component subroutines in order to verify its capabilities.

An important step in our ability to make direct comparisons between model predictions and actual Magsat perturbations has been made during this quarter by additional software that allows us to calculate along an actual Magsat orbit the magnetic perturbations that would be seen at the satellite for an assumed current distribution. This paves the way for direct comparison between measured and predicted perturbation fields and will permit a process of iteration on the input current system that yields the best fit between the measured and predicted magnetic perturbations.

3. Other Activities

During this quarter a paper describing initial findings of our polar current system modeling has been prepared and submitted for publication to the Geophysical Research Letters. This paper, entitled "A Technique for Modeling the Magnetic Perturbations produced by Field-Aligned Current Systems" makes the following major points:

1. Significant magnetic field perturbations due to auroral zone currents extend to latitudes well equatorward of those normally associated with the auroral zone, even when no currents flow at these low latitudes. The implication is that spherical harmonic models of the earth's main magnetic field may be subject to contamination from external current effects even when data is used only within $+50^\circ$ to -50° latitude.
2. For a balanced Birkeland current system in which all of the field-aligned current closes in the north-south direction between the Region 1 and Region 2 current sheets, the model predicts that there will still be a so-called "polar top-hat" in the east-west magnetic field perturbation over the polar cap. Hence the existence of a polar top-hat should not be interpreted to imply a net field-aligned current in the Region 1 system. Furthermore, such a top-hat perturbation does not require a cross polar cap current, as has been suggested by some researchers.

III. PROBLEMS ENCOUNTERED AND RECOMMENDATIONS

An anomaly has appeared during attempts to read a number of Magsat data tapes. It appears that some fraction of the 1600 bpi chronfin tapes received at UTD contain segments of repeated duplication of certain records which has so far prevented analysis of the magnetometer data during these times. The exact source of the problem has not definitely been located at this writing and attempts are continuing to pinpoint its exact cause and find a solution.

IV. PLANS FOR NEXT REPORTING INTERVAL

The primary goal of this investigative effort is to develop field modeling techniques for the near-earth magnetic field arising from external currents. Such development cannot successfully be carried out without concomitant study and analysis of the actual Magsat data. Hence during the forthcoming quarter emphasis

will be placed on the use of Magsat data to guide our selection of input current systems for direct comparison between predicted magnetic perturbations and those derived from the Magsat data.

The linear element field modeling procedure will continue to undergo extensive testing during the next reporting period. The emphasis will be placed upon utilizing the flexibility built into the software to choose diverse sets of initial current configurations. This built-in flexibility will allow us to further "prove out" the model by comparing the results of our predictive capability with those of the National Research Council of Canada group who are using a modified Kisabeth technique to compute the magnetic perturbations that arise from an assumed current distribution. Previous discussions with a representative of this group have resulted in agreement on an input current configuration and a set of locations for modeling the resulting field perturbations. We also expect to conduct more extensive comparative testing of our model with the Alaska group, who under the direction of S-I Akasofu, have also been using the Kisabeth technique to model the current distributions that produce magnetic perturbations in the observations from a meridian chain of magnetometers located in Alaska.

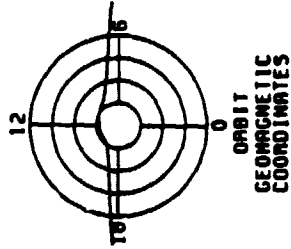
It is also planned that the modeling technique should ultimately include effects due to currents in the S_q current system and in the equatorial electrojet. These currents have not until now been included in the model. During the forthcoming quarter we will begin to develop a model of the magnetic field due to these currents that can be added to the polar current effects presently being analyzed.

V. FUNDS EXPENDED

The total expenditure of funds under this contract through the end of this reporting period (December 31, 1981) is estimated to be \$38,200.00.

MAGSAT

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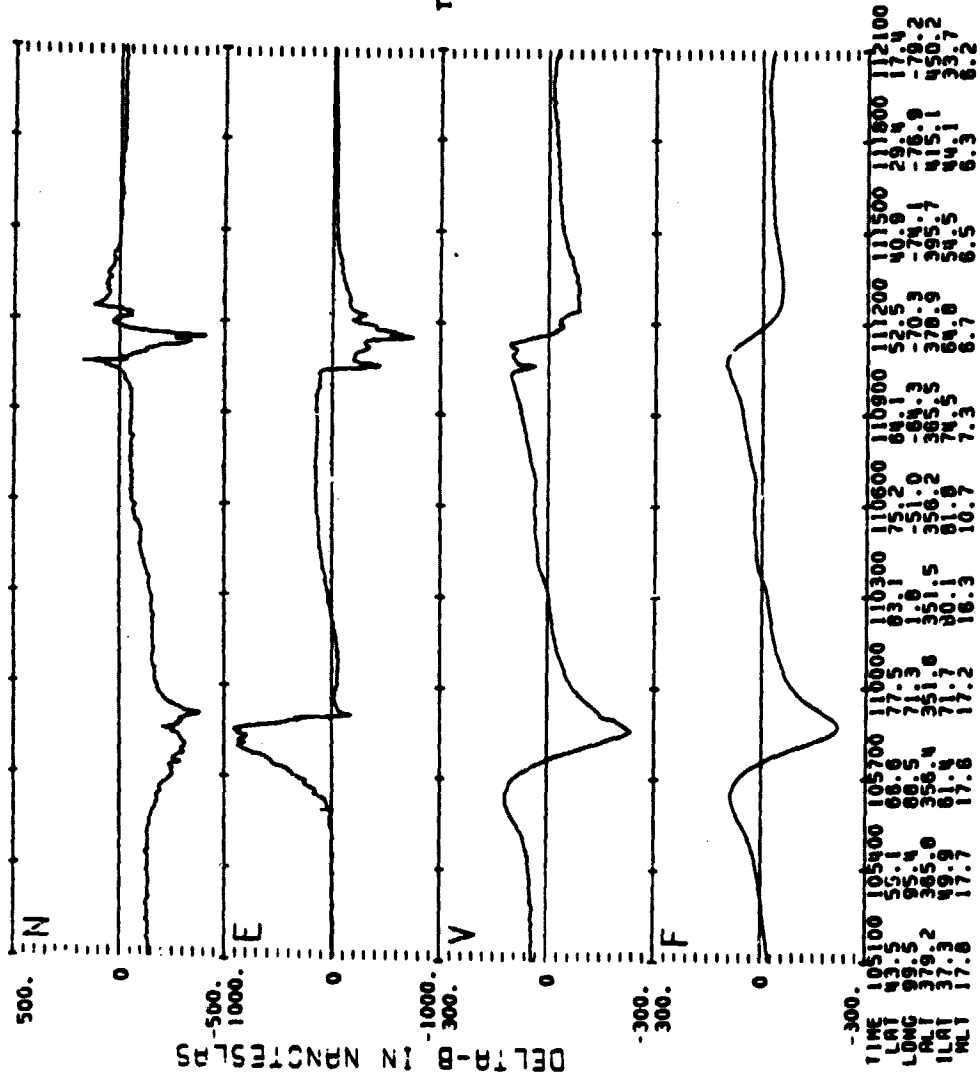
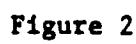


Figure 1

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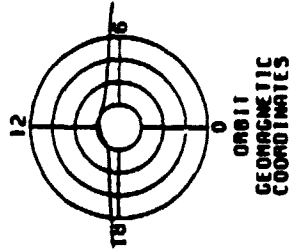


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MAGSAT

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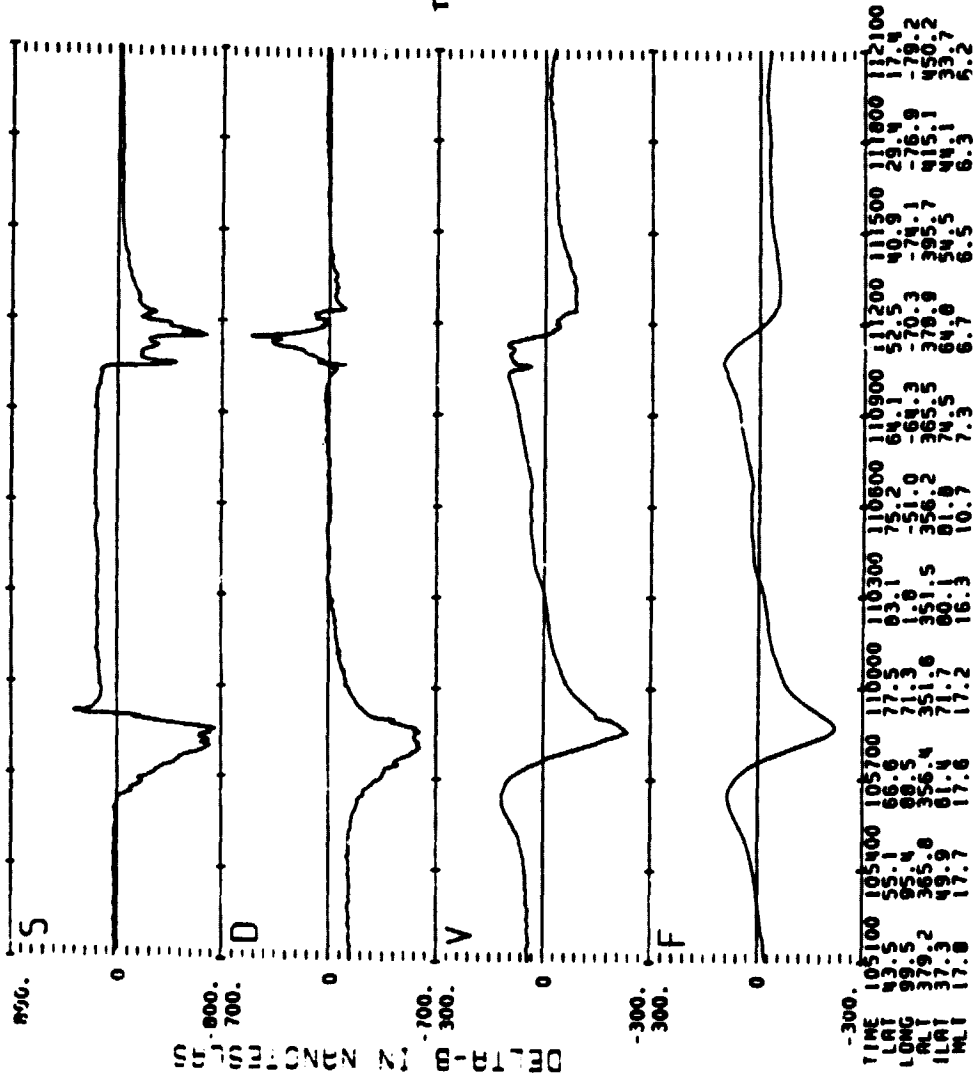


Figure 3